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PROGRESS OF BREEDING INVESTIGATIONS WITH HEVEA BRASILIENSIS II

THE CROSSES MADE IN THE YEARS 1937-1941

C. C. T. Sharp

Summary

The results up to the end of 1950 of the breeding and selection work initiated in the years 1937 to 1941 are described.

The yields and vegetative characteristics of the more important families of hand-pollinated seedlings are discussed.

The effect of inbreeding on girth and yield and the occurrence of yellow-leaved seedlings are noted.

Recommendations are made on the basis of the results obtained for the choice of clones to be used in seed gardens for producing seed for commercial planting.

A preliminary note is made on the selection for testing on a large scale of what appears to be the best 31 clones of the 1,700 established from hand-pollinated seedlings.

(1) Introduction

The breeding and selection of improved strains of rubber planting material at the Rubber Research Institute have taken place in three stages.

The first stage consisted of the work started by Morris in the years 1928-1932. After the retrenchment of staff that took place in 1932 as a result of the great industrial depression no new work was undertaken but the seedling families and the clones derived from them were kept under observation and during the years 1937-1941 the clones of the R.R.I.500 Series were selected for testing on a large scale and for distribution to estates. An account of the first stage has been given in an earlier publication. (Sharp 1940).

The second stage commenced in 1937 and use was made of the material planted on the R.R.I. Experiment Station which included most of the more promising clones which had been developed up to that time in Malaya,

Java and Sumatra. This stage continued up to the end of 1941 when it was terminated abruptly by the Japanese invasion and occupation of Malaya.

Breeding and selection were resumed after the re-occupation of Malaya and the third stage which commenced in 1947 is still in progress.

This paper describes the results obtained up to the end of 1950 from testing the material raised during the second stage.

(2) Experimental Procedure

In each of the years 1937 to 1941 a programme of hand pollinations was undertaken in the main flowering season in the early months of the year. Since the seedlings raised in the seven flowering seasons of the first stage of plant breeding were described as series 1 to 7, those raised during the second stage have been given the serial numbers 8 to 12.

The fruits were harvested in August-September and the seeds were planted in baskets in a rat-proof germination cage. When the young plants were about one foot high they were transplanted in their baskets to the seedling nursery where they remained for two years. This long period in the nursery was made necessary by the slow early growth in a deep sandy soil with poor water retaining properties. Under more favourable conditions it should be possible to shorten it considerably.

The seedlings were cut back in the nursery at about two feet from the ground and the tops were usd as budwood for establishing clones for testing on a small scale in fields previously planted for the purpose with unselected seedling stocks. Replication was considered impracticable owing to the very large areas that would be required and the first evaluation of the clones has therefore had to depend on a single direct comparison with the control clone B.84 which was budded on about one eighth of the area in rows of about seven trees distributed evenly throughout the test fields.

Since all the available budwood of each clone had to be used in the first budding round no supply budding could be undertaken. The stocks were therefore planted at a stand of over 200 to the acre and wherever possible at least two buddings were made at each planting point. This afforded ample scope for thinning out and a very uniform stand of buddings was obtained by reducing the

stand to one tree per planting point a year after budding and by further reducing the stand to 140 trees to the acre just before bringing the trees into tapping. Owing to the Japanese occupation the final thinning out of the clones made from the eighth and ninth series of seedlings was delayed.

After field budding was completed the seedling stumps were planted in replicated experiments with the modified randomised block design first described by Hutchinson and Panse (1937). Plots of buddings of B.84 were used as controls.

Some departures were unavoidably made from the procedure described above. The 1940 and 1941 hand-pollinated seedlings were planted in the field during the Japanese occupation without replication or controls and owing to the lack of suitable land in 1943, clones for testing on a small scale could not be made from the twelfth series of seedlings.

The details of planting the new clones and families of seedlings are summarised below:

Series	Date of making crosses	Legitimate Seedlings		New clones
		Date of planting	Field	Fields
8	1937	October 1939	33B	32; 33
9	1938	October 1940	34A	34; 44
10	1939	November 1941	38A	38
11	1940	November 1942	45A	41; 42
12	1941	October 1943	45B	—

Tapping and recording the yields.

The fields containing the new material were brought into tapping at various times as the trees reached tappable size and were tapped S/2, d/2, 100%.

On two normal tapping days in each month the latex of all the trees under test was coagulated in the cups by the addition of a small quantity of formic acid. The coagulated lumps were air-dried for a month and then weighed, a reduction of ten per cent for residual moisture being made. The yield of each seedling tree was recorded separately but the yields of all trees of

TABLE I

Clones used as Parents

Clone	Abbreviation	Series where used	Clone	Abbreviation	Series where used
Rubber Research Institute (R.R.I.) 500 ..	500	9.10.11.12	Tjirandji 1	Tj.1	8.9.10.11.12
" " " " 501 ..	501	9.10.11.12	" 16	Tj.16	9
" " " " 504 ..	504	9	Prang Besar 24	P.B.24	8
" " " " 505 ..	505	12	" " 49	P.B.49	8
" " " " 506 ..	506	9.12	" " 86	P.B.86	8
" " " " 507 ..	507	9	" " 186	P.B.186	8
" " " " 509 ..	509	9.12	Pilmoor A.44	A.44	8
" " " " 511 ..	511	9.11	" B.58	B.58	8
" " " " 512 ..	512	12	" B.84	B.84	8.9.10.11.12
" " " " 514 ..	514	12	AVROS 33	Av.33	8
" " " " 523 ..	523	11.12	" 157	Av.157	8
" " " " 524 ..	524	11.12	Glenshiel 1	Gl.1	8
" " " " 525 ..	525	11.12	Bodjong Datar 5	B.D.5	8
" " " " 526 ..	526	11	Lunderston N	Lun.N	Lun.N.
" " " " 527 ..	527	11	Bogor Redjo 2	B.R.2	B.R.2
" " " " 528 ..	528	11	—	—	—
" " " " 529 ..	529	11.12	—	—	—

each new clone and of each control plot were weighed together.

The trees affected with brown bast were taken out of tapping and thereafter inspected at intervals of about six months. Those which at each inspection had recovered or appeared to have recovered were brought into tapping and no reduction in the intensity of the tapping system was made. In the records of the incidence of brown bast which appear below, no tree occurs more than once even though it may have been taken out of tapping on several occasions on account of this disease.

(3) The Legitimate Seedling Families

In Table I the full names of the 32 clones used as parents of the five series of seedling families are listed together with the abbreviations used in the text and tables. For ease of reference the series in which each parent was used have also been given.

The yields of the five series of crosses and notes on their vegetative and other characteristics are described below.

SERIES 8.

Planted in Field 33B as two-year-old stumps in October 1939 (Tables II, III, IV and V). From the little evidence available at the time that the crosses were made, clones Tjirandji 1, Avros 157 and Pilmoor B.84 appeared to be amongst the best parent clones in Java, Sumatra and Malaya respectively. These three clones were therefore crossed with each other and with seven other clones, P.B.86, 24, 49 and 186, Av.33, Gl.1 and B.D.5.

Two other families, Tj.1 x Pilmoor B.58 and Pilmoor A.44 x Avros 157 were also raised. P.B.186 flowered very late in the season and crosses with this clone and Avros 157 which had by then ceased to flower could not be made.

The Error of the Experiment.

The experiment was laid out in a large number of plots of four trees in a design first used by Hutchinson and Panse. One of the objects of this design was to provide for measurement of the genetic variance of the different families but owing to the heavy loss of trees

TABLE

Legitimate Seedlings, Series 8. Plant

Yield in lb. per tree per annum (estimated on 160 t

Parents		Tj. 1 1946	1947	1948	1949	1950	Mean 1946 to 1950	Avros 157 1946	1947	1948	1949	1950
P.B. 86	(i)	57	52	54	57	57		52	51	51	50	52
	(ii)	8.0	11.3	9.5	12.8	13.2	11.0	7.8	13.0	10.8	17.0	19.8
	(iii)	129	112	96	118	119		126	129	109	157	178
P.B. 24	(i)	25	24	23	23	22		18	18	17	17	17
	(ii)	11.6	18.0	18.1	21.1	21.8	18.1	6.7	15.7	13.6	17.9	22.4
	(iii)	187	178	183	195	196		108	155	137	166	202
P.B. 49	(i)	44	43	42	39	40		48	46	46	46	46
	(ii)	15.4	22.1	19.2	23.1	24.5	20.9	11.8	18.6	16.4	19.5	24.5
	(iii)	248	219	194	213	221		190	184	166	180	221
P.B. 186	(i)	31	29	27	27	26						
	(ii)	8.0	14.4	11.9	16.4	19.2	14.0	—	—	—	—	—
	(iii)	129	143	120	152	173						
Av. 33	(i)	30	28	27	25	24		3	2	2	1	1
	(ii)	11.1	16.9	17.3	19.5	19.9	16.9	9.1	10.7	7.8	10.3	9.7
	(iii)	179	167	175	180	179		147	106	79	95	87
Av. 157	(i)	14	13	14	13	13						
	(ii)	6.6	16.3	13.9	18.4	20.8	15.2	—	—	—	—	—
	(iii)	106	161	140	170	187						
A. 44	(i)							9	9	8	8	8
	(ii)	—	—	—	—	—	—	7.4	10.9	9.3	12.4	15.2
	(iii)							109	108	94	115	137
B. 84	(i)	2	2	2	3	4		19	19	17	16	16
	(ii)	6.7	11.5	10.3	14.5	10.8	10.8	9.9	17.9	15.8	21.8	23.4
	(iii)	108	114	104	134	97		160	177	160	201	211
B. 58	(i)	50	49	52	50	48						
	(ii)	9.0	13.0	11.5	14.8	14.7	12.6	—	—	—	—	—
	iii)	145	129	116	137	132						
Tj. 1	(i)							14	13	14	13	13
	(ii)	—	—	—	—	—	—	6.6	16.3	13.9	18.4	20.8
	(iii)							106	161	140	170	187
Gl. 1	(i)	23	21	22	24	25		14	14	14	14	15
	(ii)	7.3	10.9	10.5	13.1	14.1	11.2	6.3	11.3	9.8	13.2	17.8
	(iii)	118	108	106	121	127		102	112	99	122	160
B.D. 5	(i)	4	4	4	3	4		21	21	22	21	20
	(ii)	5.8	11.0	9.0	16.0	16.0	11.6	7.2	14.3	10.9	14.0	13.6
	(iii)	94	109	91	148	144		116	142	110	129	123
MEAN	(ii)	8.9	14.5	13.1	17.0	17.5		8.1	14.3	12.0	16.0	18.6

Control Buddings of Pilmoor B.84 (124 trees).
Yield in lb. per tree per annum of 160 tappings.

1946	1947	1948	1949	1950
6.2	10.1	9.9	10.8	11.1

Note 1. (i) = No. of trees tapped; (ii) = Yield in lb.; (iii) = Yield as % of c

Note 2. The seedling trees were opened for tapping at 20 inches from the
The budded trees were opened for tapping at 40 inches from the

II

ed October 1939—Field 33 B.

ppings) and as a percentage of the control.

Mean 1946 to 1950	B. 84					Mean 1946 to 1950	Mean				
	1946	1947	1948	1949	1950		1946	1947	1948	1949	1950
13.7	27 9.0 145	23 12.4 123	27 9.4 95	27 11.2 104	25 11.8 106	10.8	8.3	12.2	9.9	13.6	14.8
15.3	25 12.9 208	19 17.9 177	18 13.9 140	15 15.9 147	15 13.1 118	14.7	10.4	17.2	15.2	18.3	19.1
18.2	38 12.9 208	37 14.7 146	36 11.9 120	35 15.6 144	32 17.9 161	14.6	13.4	18.5	15.8	19.1	22.3
—	7 8.1 131	6 12.4 123	7 12.1 122	6 20.0 185	6 17.0 153	13.9	8.1	13.4	12.0	18.2	18.1
9.5	5 10.9 176	5 13.7 136	5 15.5 157	4 14.8 137	2 13.3 120	13.6	10.4	13.8	13.5	14.8	14.3
—	19 9.9 160	19 17.9 177	17 15.8 160	16 21.8 201	16 23.4 211	17.8	8.3	17.1	14.9	20.1	22.1
11.0	—	—	—	—	—	—	7.4	10.9	9.3	12.4	15.2
17.8	—	—	—	—	—	—	8.3	14.7	13.1	18.1	17.1
—	—	—	—	—	—	—	9.0	13.0	11.5	14.8	14.7
15.2	2 6.7 108	2 11.5 114	2 10.5 104	3 14.5 134	4 10.8 97	10.8	6.7	13.9	12.1	16.4	15.8
11.7	5 7.6 123	4 11.9 118	5 8.3 86	5 12.5 116	6 14.7 132	11.0	7.1	11.4	9.6	12.9	15.5
12.0	28 9.5 150	27 12.7 126	25 11.6 117	24 14.3 132	25 13.4 121	12.3	7.4	12.7	10.5	14.7	14.3
	9.7	13.9	12.1	15.6	15.0		8.9	14.1	12.3	16.2	17.0

ntrol.

round in April 1946 and 30 inches from ground in January 1948.

union in April 1946 and the second panel at the same height in May 1950.

TA

Legitimate Seedli

Differences in Mean Yields (

Parents	Standard error	Pil.B.84 x P.B.186	Pil.B.84 x B.D.5	Pil.B.84 x Gl.1	Pil.B.84 x Av.33	Pil.B.84 x P.B.49	Pil.B.84 x P.B.24	Pil.B.84 x P.B.86	Av.157 x Pil.A.44	Av.157 x Pil.B.84	Av.157 x B.D.5
Tj.1 x P.B.86	0.5	2.9	1.3	0	2.6	3.6*	3.7*	– 0.2	0	6.8*	1.0
„ x P.B.24	0.8	– 4.2*	– 5.8*	– 7.1*	– 4.5*	– 3.5*	– 3.4*	– 7.3*	– 7.1*	– 0.3	– 6.1*
„ x P.B.49	0.6	– 7.0*	– 8.6*	– 9.9*	– 7.3*	– 6.3*	– 6.2*	–10.1*	– 9.9*	– 3.1*	– 8.9*
„ x Av.33	0.8	– 3.0	– 4.6*	– 5.9*	– 3.3	– 2.3*	– 2.2	– 6.1*	– 5.9*	0.9	– 4.9*
„ x Gl.1	0.8	2.7	1.1	– 0.2	2.4	3.4*	3.5*	– 0.4	– 0.2	6.6*	0.8
„ x B.D.5	2.0	2.3	0.7	– 0.6	2.0	3.0	3.1	– 0.8	– 0.6	6.2*	0.4
„ x P.B.186	0.8	– 0.1	– 1.7	– 3.0	– 0.4	0.6	0.7	– 3.2*	– 3.0	3.8*	– 2.0
„ x Av.157	1.1	– 1.3	– 2.9*	– 4.2*	– 1.6	– 0.6	– 0.5	– 4.4*	– 4.2*	2.6	– 3.2*
„ x Pil.B.84	2.3	3.1	1.5	0.2	2.8	3.8	3.9	0	0.2	7.0*	1.2
„ x Pil.B.58	0.6	1.3	– 0.3	– 1.6	1.0	2.0*	2.1	– 1.8	– 1.6	5.2*	– 0.6
Av.157 x P.B.86	0.6	0.2	– 1.4	– 2.7	– 0.1	0.9	1.0	– 2.9*	– 2.7	4.1*	– 1.7
„ x P.B.24	1.0	– 1.4	– 3.0*	– 4.3*	– 1.7	– 0.7	– 0.6	– 4.5*	– 4.3*	2.5	– 3.3*
„ x P.B.49	0.6	– 4.3*	– 5.9*	– 7.2*	– 4.6*	– 3.6*	– 3.5*	– 7.4*	– 7.2*	– 0.4	– 6.2*
„ x Av.33	2.8	4.4	2.8	1.5	4.1	5.1	5.2	1.3	1.5	8.3*	2.5
„ x Gl.1	1.1	2.2	0.6	– 0.7	1.9	2.9*	3.0*	– 0.9	– 0.7	6.1*	0.3
„ x B.D.5	0.9	1.9	0.3	– 1.0	1.6	2.6*	2.7*	– 1.2	– 1.0	5.8*	
„ x Pil.B.84	0.9	– 3.9*	– 5.5*	– 6.8*	– 4.2	– 3.2*	– 3.1*	– 7.0*	– 6.8*		
„ x Pil.A.44	1.4	2.9	1.3	0	2.6	3.6*	3.7*	– 0.2			
Pil.B.84 x P.B.86	0.8	3.1	1.5	0.2	2.8	3.8*	3.9*				
„ x P.B.24	0.9	– 0.8	– 2.4*	– 3.7	– 1.1	– 0.1					
„ x P.B.49	0.7	– 0.7	– 2.3*	– 3.6	– 1.0						
„ x Av.33	2.0	0.3	– 1.3	– 2.6							
„ x Gl.1	1.8	2.9	1.3								
„ x B.D.5	0.8	1.6									
„ x P.B.186	1.6										

Figures in the table show differences in mean yield in lb./tree/annum. A nega
family. Differences exceeding the 5% level of significance are denoted

Some families are represented by few trees and hence comparisons involving t

BLE III

gs Series 8—Field 33 B.
lb./tree/annum) and Standard Errors.

Av.157 x Gl.1	Av.157 x Av.33	Av.157 x P.B.49	Av.157 x P.B.24	Av.157 x P.B.86	Tj.1 x Pil.B.58	Tj.1 x Pil.B.84	Tj.1 x Av.157	Tj.1 x P.B.186	Tj.1 x B.D.5	Tj.1 x Gl.1	Tj.1 x Av.33	Tj.1 x P.B.49	Tj.1 x P.B.24	Tj.1 x P.B.86
0.7	– 1.5	7.2*	4.3*	2.7*	1.6*	– 0.2	4.2*	3.0*	0.6	0.2	5.9*	9.9*	7.1*	
– 6.4*	– 8.6*	0.1	– 2.8*	– 4.4*	– 5.5*	– 7.3*	– 2.9*	– 4.1*	– 6.5*	– 6.9*	– 1.2	2.8*		
– 9.2*	–11.4*	– 2.7*	– 5.6*	– 7.2*	– 8.3*	–10.1*	– 5.7*	– 6.9*	– 9.3*	– 9.7*	– 4.0*			
– 5.2*	– 7.4*	1.3	– 1.6	– 3.2*	– 4.3*	– 6.1*	– 1.7	– 2.9*	– 5.3*	– 5.7*				
0.5	– 1.7	7.0*	4.1*	2.5*	1.4	– 0.4	4.0*	2.8*	0.4					
0.1	– 2.1	6.6*	3.7	2.1	1.0	– 0.8	3.6	2.4						
– 2.3	– 4.5	4.2*	1.3	– 0.3	– 1.4	– 3.2	1.2							
– 3.5*	– 5.7	3.0*	0.1	– 1.5	– 2.6*	– 4.4								
0.9	– 1.3	7.4*	4.5	2.9	1.8									
– 0.9	– 3.1	5.6*	2.7*	1.1										
– 2.0	– 4.2	4.5*	1.6											
– 3.6*	– 5.8	2.9*												
– 6.5*	– 8.7*													
2.2														

tive sign indicates that the 'column' family has a smaller mean yield than the 'row'
by an asterisk.

hese families will require relatively larger numerical differences to reach significance.

TABLE

Legitimate Seedlings, Ser

Incidence of Brown Bast in the f

Parents	Tjirandji 1						Avros 157				
	Total trees tapped	Cases of Brown Bast					Total trees tapped	Cases of Brown			
		1946	1947	1948	1949	1950	Total		1946	1947	1948	1949
P.B. 86 -	62	1	7	1	—	3	12	55	—	3	3	—
P.B. 24 -	25	—	5	2	1	1	9	18	—	—	1	—
P.B. 49 -	45	—	1	3	1	3	8	49	—	1	1	—
P.B.186 -	31	1	1	4	—	3	9	—	—	—	—	—
Av. 33 -	30	—	4	4	—	1	9	3	—	1	1	—
Av.157 -	14	—	2	1	—	3	6	—	—	—	—	—
A.44 -	—	—	—	—	—	—	—	9	—	1	—	—
B.84 -	4	—	—	—	—	—	—	19	—	1	1	—
B.58 -	52	—	4	—	1	4	9	—	—	—	—	—
Tj.1 -	—	—	—	—	—	—	—	14	—	2	1	—
Gl.1 -	28	—	4	2	—	—	6	16	—	—	1	—
B.D.5 -	4	—	—	2	—	—	2	23	—	1	3	1
Total -	295	2	28	19	3	18	70	206	—	10	12	1
Percent -							24					

Note: (1) Total trees tapped include all trees that have been tapped at any time duri

(2) Trees affected more than once with brown bast appear only once in the

IV

es 8.—Field 33 B.

rst five years of Tapping.

Bast		Pilmoor B.84							Tj.1, Av.157 & B.84 Combined		
		Total trees tapped	Cases of Brown Bast						Total trees tapped	Cases of Brown Bast	
950	Total		1946	1947	1948	1949	1950	Total		Total	Percentage
4	10	30	1	4	—	1	2	8	147	30	20
2	3	25	—	5	5	3	2	15	68	27	40
1	3	38	—	3	1	2	—	6	132	17	13
—	—	7	—	1	1	—	—	2	38	11	29
—	2	5	—	2	1	—	1	4	38	15	39
—	—	19	—	1	1	—	2	4	33	10	30
—	1	—	—	—	—	—	—	—	9	1	11
2	4	—	—	—	—	—	—	—	23	4	17
—	—	—	—	—	—	—	—	—	52	9	17
—	3	4	—	—	—	—	—	—	18	3	17
—	1	6	—	1	—	—	—	1	50	8	16
—	5	28	—	1	2	2	1	6	55	13	24
9	32	162	1	18	11	8	8	46	663	148	—
	16							28			22

g the years 1946-1950.

able.

TAB

Legitimate Seedlings, Series S,

Mean girth in inches at

Parents	Tj. 1				Av.	
	No. of trees	1946	1948	1950	No. of trees	1946
P.B. 86 ..	69	19.3	22.8	25.0	57	21.3
„ 24 ..	26	22.5	26.4	29.5	18	21.5
„ 49 ..	46	27.0	31.3	34.4	47	26.9
„ 186 ..	31	21.6	25.9	28.9	—	—
Av. 33 ..	30	23.3	26.2	28.6	3	24.0
„ 157 ..	16	21.5	27.5	30.8	—	—
A.44 ..	—	—	—	—	9	22.7
B.84 ..	5	15.7	21.1	23.4	19	27.5
B.58 ..	53	21.7	25.3	27.2	—	—
Tj.1 ..	—	—	—	—	16	21.5
Gl.1 ..	30	19.0	22.9	25.9	16	20.0
B.D.5 ..	5	16.5	20.2	23.0	23	21.9
Total or mean of families	311	20.8	25.0	27.7	208	23.0

Control B

No. of trees measured

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LE V

Planted October 1939, Field 33 B.
50 inches from the ground.

157			B. 84			Mean of Tj.1, Av.157 and B.84		
1948	1950	No. of trees	1946	1948	1950	1946	1948	1950
25.4	28.7	37	17.6	21.0	23.3	19.4	23.1	25.7
25.4	28.5	29	21.0	24.6	27.1	21.7	25.5	28.4
31.5	35.9	39	24.5	29.5	32.7	26.1	30.8	34.3
—	—	8	20.2	25.8	29.4	20.9	25.8	29.1
26.4	28.0	5	24.5	27.5	29.7	23.9	26.7	28.8
—	—	19	27.5	32.4	36.7	24.5	30.0	33.7
25.9	28.4	—	—	—	—	22.7	25.9	28.4
32.4	36.7	—	—	—	—	21.6	26.7	30.0
—	—	—	—	—	—	21.7	25.3	27.2
27.5	30.8	5	15.7	21.1	23.4	18.6	24.3	27.1
26.5	29.1	8	19.4	22.7	25.7	19.8	24.0	26.9
25.8	26.9	32	20.5	23.7	25.5	19.6	23.2	25.1
27.4	30.3	182	21.2	25.4	28.2	21.7	25.9	28.7

ddings of B.84

Mean girth Inches		
1946	1948	1950
22.4	26.2	29.2

during the first few years from root disease and attacks by termites this measurement could not be made.

The number of trees in each family varies greatly and it is not possible to make a single estimate of the error which would be used for testing the significance of the difference in yield between any two families. The error of the mean yield for five years of each family has therefore been calculated separately and the differences in mean yield of the various families are set out in Table III with an indication of what differences are significant at the five per cent level.

Comparison of Tj.1, Av.157 and B.84 as parents.

The first comparison can be made between Tj.1 and Av.157 when crossed with P.B.86, P.B.24, P.B.49, Av.33, Gl.1, B.D.5 and B.84. The unweighted mean of the Tj.1 families derived from crosses with these clones is 14.3 ± 0.5 pounds per tree per annum and that of the Av.157 families 14.0 ± 0.5. The difference, 0.3 ± 0.7, is not significant. It will however be observed that although the mean yields of these two groups of families do not differ significantly, the family Tj.1 x P.B.24 has a significantly higher yield than Av.157 x P.B.24 and in the reverse direction the yield of Tj.1 x P.B.86 is significantly lower than Av.157 x P.B.86.

A similar comparison can be made between the Tj.1 and B.84 families when crossed with P.B.86, P.B.24, P.B.49, Av.33, Gl.1, B.D.5, P.B.186 and Av.157. The unweighted mean of the Tj.1 families of crosses with these clones is 14.9 ± 0.4 pounds per tree per annum and that of the B.84 families 13.6 ± 0.5. The difference of 1.3 ± 0.6 pounds is significant, but that crosses with Tj.1 are not always superior to those with B.84 is shown when the two clones are crossed with Av.157.

The mean yields of the Av.157 and B.84 families may also be compared when crossed with P.B.86, P.B.24, P.B.49, Av.33, Gl.1, B.D.5 and Tj.1. In this case the unweighted mean of the crosses with Av.157 is 13.6 ± 0.5 pounds per tree per annum and that of the crosses with B.84 is 12.6 ± 0.6. The mean difference, 1.0 ± 0.8, is not significant though significant differences occur when the two clones are crossed with, for example, P.B.49 and P.B.86.

From the data obtained from the eighth series of crosses it may be concluded that Tj.1 has shown itself on the average to be a better producer of high yielding seedlings than B.84. Tj.1 may also be superior in this respect to Av.157 and Av.157 to B.84 but this has not been demonstrated.

It may also be seen from Table V that Av.157 produces more vigorous seedlings than either Tj.1 or B.84.

About one quarter of the trees of the B.84 and Tj.1 families of seedlings succumbed to brown bast during the first five years of tapping compared with sixteen per cent in the Avros 157 families.

Comparison of the other clones used as parents in the eighth series.

Of the other clones used, P.B.49 produced very high yielding families of seedlings with exceptionally vigorous growth and a low incidence of brown bast. On the other hand the renewed bark of the three families of P.B.49 seedlings tends to be rather corrugated. Buddings of B.84 frequently show this characteristic and the corrugations are particularly marked in the cross P.B.49 x B.84. It is known that the renewed bark of B.84 tends to grow smoother with age, the corrugations seldom causing any serious interference with tapping, and the indications are that the seedlings of this family will behave in the same way.

The latex of young buddings of P.B.49 shows a tendency to coagulate prematurely before collection and this characteristic was observed in July 1947 in about one third of the seedling trees of the three P.B.49 families. From observations taken at the same time it was also observed that about two thirds of the clones derived from these seedlings showed partial or complete coagulation of the latex. A second examination was made in July 1951 and a considerable improvement had taken place, precoagulation occurring in only nine per cent of the seedling trees and in fifteen per cent of the clones.

P.B.24 and Av.33 also produced high yielding families but since some 40 per cent of the trees contracted brown bast during the first five years of tapping their commercial value would be low.

TABLE

Legitimate Seedlings, Series 9. Plan

Yield in lb. per tree per annum (estimated on 160 tappings

Family	Parents	No. of trees measured	Girth at 50 inches from ground. Inches.				No. of trees tapped
			1946	1948	1949	1950	
500 x 501 -	A.44 x B.84 & A.44 x Lun.N -	9	18.7	21.3	22.1	22.7	8
„ x 504 -	-do- & -do- -	78	21.3	24.9	26.0	27.0	70
„ x 509 -	-do- & -do- -	1	18.1	21.2	23.3	24.3	1
„ x 511 -	-do- & A.44 x B.16 -	11	19.0	25.4	26.8	26.6	8
„ x Tj.1 -	-do- & Unknown -	10	23.2	28.6	30.8	32.5	8
„ x B.84 -	-do- & -do- -	1	15.8	17.5	18.1	19.0	1
501 x 506 -	A.44 x Lun.N & A.44 x B.84 -	18	20.0	24.0	25.8	27.1	15
„ x 509 -	-do- & A.44 x Lun.N	6	15.6	18.9	19.5	19.9	6
„ x 511 -	-do- & A.44 x B.16 -	41	21.7	27.0	27.5	28.7	34
„ x Tj.1 -	-do- & Unknown -	29	21.6	26.4	27.9	28.5	24
„ x B.84 -	-do- & -do- -	11	25.5	30.0	31.9	33.5	11
504 x 506 -	-do- & A.44 x B.84 -	15	22.0	25.4	27.0	27.9	15
„ x 509 -	-do- & A.44 x Lun.N	40	18.8	21.7	22.5	23.0	37
„ x 511 -	-do- & A.44 x B.16 -	66	19.1	24.1	25.8	26.6	56
„ x Tj.1 -	-do- & Unknown -	71	21.4	26.9	28.8	30.2	62
„ x B.84 -	-do- & -do- -	25	20.8	24.9	26.6	27.5	24
507 x Tj.1 -	A.44 x B.84 & -do- -	19	23.8	29.1	30.3	31.9	16
509 x 511 -	A.44 x Lun.N & A.44 x B.16 -	7	21.1	24.3	25.2	26.3	6
„ x Tj.1 -	-do- & Unknown -	4	24.3	30.0	31.7	32.8	4
511 x Tj.1 -	A.44 x B.16 & -do- -	12	20.7	26.1	27.8	29.1	11
„ x B.84 -	-do- & -do- -	6	25.3	32.6	34.3	35.4	6
Tj.1 x Tj.16 -	Unknown & -do- -	27	22.2	28.9	30.9	32.5	22
„ x B.84 -	-do- & -do- -	17	22.8	27.9	29.8	30.6	16
Total or Mean of families		524	21.0	25.5	27.0	28.0	461
Control Buddings of B.84		120	19.7	26.4	28.5	29.6	109

Note: (1) The yields for the year 1946 have been estimated from the yields of

(2) The seedling trees were opened for tapping at 20 inches from the gr

The budded trees were opened at 40 inches from the union in May 194

VI

October 1940 in Field 34 A.
girth measurements and incidence of Brown Bast.

Yield in lb. per tree per annum and as % of control										Mean 1946 to 1950	Incidence of Brown Bast						
1946		1947		1948		1949		1950			1946	1947	1948	1949	1950	Total	% of trees tapped
lb.	%	lb.	%	lb.	%	lb.	%	lb.	%								
8.6	183	12.6	173	12.9	170	12.5	135	9.5	98	11.2	—	—	—	—	—	—	—
11.0	234	14.2	195	13.5	178	13.6	147	13.5	139	13.2	3	5	16	6	10	40	57
9.8	209	14.9	204	12.3	162	—	—	—	—	—	—	—	1	—	—	1	100
10.8	230	13.5	185	16.2	213	10.5	114	11.6	120	12.5	3	—	2	1	1	7	88
13.8	294	19.2	263	18.7	246	16.5	179	15.9	164	16.8	1	—	4	—	3	8	100
4.3	91	3.2	44	3.3	43	3.4	37	—	—	—	—	—	—	—	1	1	100
9.2	196	10.4	142	10.6	139	9.6	104	7.6	78	9.5	2	2	4	3	1	12	80
6.9	147	9.7	133	8.9	117	7.5	81	10.1	104	8.6	—	—	1	—	1	2	33
10.8	230	17.2	236	17.7	233	17.9	194	18.5	191	16.4	—	4	5	3	5	17	50
8.1	172	19.5	267	19.6	258	20.6	224	20.8	214	17.7	—	2	5	2	2	11	46
14.0	298	20.1	275	19.9	262	20.2	219	23.0	237	19.4	—	—	3	2	5	10	83
9.2	196	11.6	159	11.5	151	13.8	149	12.2	126	11.7	—	—	2	1	3	6	40
9.7	206	13.4	184	12.2	161	11.5	124	11.6	120	11.7	4	—	6	1	1	12	32
8.7	185	12.4	170	13.6	179	13.8	149	12.9	133	12.3	1	1	9	7	5	23	41
9.3	198	15.6	214	16.2	213	18.2	196	17.2	177	15.3	5	—	8	3	14	30	48
8.4	179	11.2	153	11.5	151	13.3	144	13.5	139	11.6	—	1	3	—	4	8	33
14.1	300	18.7	256	18.5	243	20.8	225	18.8	194	18.2	1	—	9	2	1	13	81
10.1	215	11.7	160	11.6	153	13.5	146	8.6	89	11.1	1	—	2	—	3	6	100
13.8	294	21.9	300	27.6	363	30.9	334	33.1	341	25.5	—	—	—	—	1	1	20
7.3	155	12.0	164	12.0	158	16.7	180	15.2	157	12.6	1	—	2	—	3	6	55
9.9	211	14.7	201	16.7	220	25.1	272	24.3	251	18.1	1	—	1	—	—	2	33
10.4	221	17.5	240	19.5	256	24.6	267	21.0	216	18.6	1	2	5	1	3	12	55
8.6	183	12.6	173	13.7	180	16.7	180	16.9	174	13.7	—	2	3	1	4	10	63
										—	24	19	91	33	71	238	59
4.7	100	7.3	100	7.6	100	9.2	100	9.7	100	7.7	—	2	3	4	3	12	11

ay-October.

d in May 1946 and the second panel at 30 inches from the ground in July 1948.

nd the second panel at the same height in August 1950.

The most important records of the four highest yielding families in this series are summarised below.

Family	No. of trees tapped	Mean Yield 1946-50 per annum	Brown Bast	Mean Girth 1950
		lb. per tree	%	inches
Tj.1 x P.B.49 ..	45	20.9	18	34.4
Av.157 x P.B.49 ..	49	18.2	6	35.9
Tj.1 x P.B.24 ..	25	18.1	36	29.5
Av.157 x B.84 ..	19	17.8	21	36.7

Of the four families the first two are of about equal value for the significantly higher yield of family Tj.1 x P.B.49 would be offset by the lower incidence of brown bast in family Av.157 x P.B.49. The third family has little practical interest owing to the high incidence of brown bast but the fourth family is exceptionally vigorous with very good bark characters and an average amount of brown bast.

P.B.86 and G.1, although amongst the highest yielders of the older clones have produced poor-yielding families in striking contrast with Av.157 which has never been recommended for commercial planting and Av.33, P.B.49 and P.B.24 which were discarded as second class clones many years ago.

Series 9.

This series was planted as two-year-old stumps in Field 34A in October 1940. (Table VI).

In this programme of pollinations clones R.R.I.500, 501, 504, 506, 507, 509 and 511 were used for the first time. They were crossed with each other in various combinations and also with B.84 and Tj.1. In addition the cross Tj.1 x Tj.16, made first at the Proefstation, West Java, was repeated.

Self-pollinated seedlings of A.44 are known to produce very poorly grown and low yielding trees and all the clones of the R.R.I.500 Series mentioned above have A.44 as one of their parents. When crossed with each other they produce high yielding families of trees but for the most part they are poorly grown showing, like the grandparent A.44, a tendency for the stems to be

fluted and the renewed bark to be corrugated. (See section (4) below).

The control clone B.84 was budded in the field at the same time that the seedling stumps were planted. The original stand of the buddings was 180 trees to the acre and it was intended that they should be thinned out to the same stand as the seedlings—109 trees to the acre—early in 1942. Thinning out however did not take place until 1946 by which time they had suffered some appreciable retardation in growth from competition with each other as a result of the high stand. There can be little doubt that compared with the control the yields of the seedlings are exaggerated, the buddings having suffered more severely than the seedlings from the effects of neglect during the war years. On the other hand the yields of the best families of seedlings, although a year younger, appear to be as good as or better than the best families in the eighth series.

The yield per tree of some of the families is high but owing to the heavy incidence of brown bast the yield per acre would in many cases be very little in excess of the control clone by the fifth year. There is no evidence from this series of crosses to show that any of the parent clones used is more likely to produce seedlings susceptible to brown bast than the others.

The original design and history of this trial were similar to those of the eighth series. It has again been necessary to calculate the standard error of each family and these with the differences in mean yield between all pairs of families can be found in Table VII.

The highest yielding families are 501 x Tj.1, 509 x Tj.1, 511 x B.84, Tj.1 x Tj.16, 501 x B.84 and 507 x Tj.1. The two last named are excessively susceptible to brown bast and need not be considered further. Of the remaining families 509 x Tj.1 is the best grown and yields significantly more than any of the others. There are only four trees in this series but a larger family of younger trees in series 12 confirms the good yields obtained here. (See Table X). The families Tj.1 x 501 and, so far as can be told from six trees, 511 x B.84 are well grown with good secondary characters and average susceptibility to brown bast for this series.

The good yields from crosses of Tj.1 x Tj.16 confirm those obtained at the Proefstation, West Java, (de Bergcultures 1941). The incidence of brown bast is

TABLE

Legitimate Seedlings S
Differences in Mean Yield (lb./t

Parents	Standard error	Tj.1 x PilB.84	Tj.1 x Tj.16	R.R.I.511 x Pil.B.84	R.R.I.511 x Tj.1	R.R.I.509 x Tj.1	R.R.I.509 x R.R.I.511	R.R.I.507 x Tj.1	R.R.I.504 x Pil.B.84	
R.R.I.500 x R.R.I.501	1.9	2.5	7.4*	6.9*	1.4	14.3*	– 0.1	7.0*	0.4	4
„ x R.R.I.504	0.6	0.5	5.4*	4.9*	– 0.6	12.3*	– 2.1	5.0*	– 1.6	2
„ x R.R.I.511	1.9	1.2	6.1*	5.6	0.1	13.0*	– 1.4	5.7*	– 0.9	2
„ x Tj.1	1.9	– 3.1	1.8	1.3	– 4.2	8.7*	– 5.7*	1.4	– 5.2*	– 1
R.R.I.501 x R.R.I.506	1.4	4.2*	9.1*	8.6*	3.1	16.0*	1.6	8.7*	2.1	5
„ x R.R.I.509	2.3	5.1	10.0*	9.5*	4.0	16.9*	2.5	9.6*	3.0	6
„ x R.R.I.511	0.9	– 2.7	2.2	1.7	– 3.8*	9.1*	– 5.3*	1.8	– 4.8*	– 1
„ x Tj.1	1.1	– 4.0*	0.9	0.4	– 5.1*	7.8*	– 6.6*	0.5	– 6.1*	– 2
„ x Pil.B.84	1.6	– 5.7*	– 0.8	– 1.3	– 6.8*	6.1*	– 8.3*	– 1.2	– 7.8*	– 4
R.R.I.504 x R.R.I.506	1.4	2.0	6.9*	6.4*	0.9	13.8*	– 0.6	6.5*	– 0.1	3
„ x R.R.I.509	0.9	2.0	6.9*	6.4*	0.9	13.8*	– 0.6	6.5*	– 0.1	3
„ x R.R.I.511	0.7	1.4	6.3*	5.8*	0.3	13.2*	– 1.2	5.9*	– 0.7	3
„ x Tj.1	0.7	– 1.6	3.3*	2.8	– 2.7	10.2*	– 4.2	2.9	– 3.7*	
„ x Pil.B.84	1.1	2.1	7.0*	6.5*	1.0	13.9*	– 0.5	6.6*		
R.R.I.507 x Tj.1	1.4	– 4.5*	0.4	– 0.1	– 5.6*	7.3*	– 7.1*			
R.R.I.509 x R.R.I.511	2.1	2.6	7.5*	7.0*	1.5	14.4*				
R.R.I.509 x Tj.1	2.5	–11.8*	– 6.9*	– 7.4*	–12.9*					
R.R.I.511 x Tj.1	1.5	1.1	6.0*	5.5*						
R.R.I.511 x Pil.B.84	2.3	– 4.4	0.5							
Tj.1 x Tj.16	1.1	– 4.9*								
Tj.1 x Pil.B.84	1.4									

A negative value indicates that the 'row' family has a greater mean yield than the '
Differences whose magnitude is such that they exceed the 5% level of significance are
Some families are represented by few trees and their yield difference from other famil

VII

ies 9—Field 34 A.
/annum) and Standard Errors.

R.R.I.504 x R.R.I.511	R.R.I.504 x R.R.I.509	R.R.I.504 x R.R.I.506	R.R.I.501 x Pil.B.84	R.R.I.501 x Tj.1	R.R.I.501 x R.R.I.511	R.R.I.501 x R.R.I.509	R.R.I.501 x R.R.I.506	R.R.I.500 x Tj.1	R.R.I.500 x R.R.I.511	R.R.I.500 x R.R.I.504	R.R.I.500 x R.R.I.501
1.1	0.5	0.5	8.2*	6.5*	5.2*	– 2.6	– 1.7	5.6*	1.3	2.0	
– 0.9	– 1.5	– 1.5	6.2*	4.5*	3.2*	– 4.6	– 3.7*	3.6	– 0.7		
– 0.2	– 0.8	– 0.8	6.9*	5.2*	3.9	– 3.9	– 3.0	4.3			
– 4.5*	– 5.1*	– 5.1*	2.6	0.9	– 0.4	– 8.2*	– 7.3*				
2.8	2.2	2.2	9.9*	8.2*	6.9*	– 0.9					
3.7	3.1	3.1	10.8*	9.1*	7.8*						
– 4.1*	– 4.7*	– 4.7*	3.0	1.3							
– 5.4*	– 6.0*	– 6.0*	1.7								
– 7.1*	– 7.7*	– 7.7*									
0.6	0										
0.6											

olumn' family.

denoted by an asterisk.

es requires to be extra large numerically before significance is established.

TABLE

Legitimate Seedlings, Series 11. Pla
Yield in lb. per tree per annum (160 tappings),

Family	Parents	No. of trees measured	Girth in inches at 5 from ground	
			Jan. 1949	Jan. 1950
Tj.1 x Lun.N	Unknown & Unknown	5	15.1	17.3
„ x 500	„ & A.44 x B.84	8	17.5	19.5
„ x 523	„ & A.44 x B.16	9	17.4	20.1
„ x 524	„ & „ „	16	17.7	19.8
„ x 525	„ & B.84 x D.65	3	15.1	17.8
„ x 526	„ & „ „	19	18.5	20.6
„ x 527	„ & B.50 x B.84	35	17.4	19.4
„ x 528	„ & B.84 x D.65	30	20.6	23.2
„ x 529	„ & „ „	13	19.8	22.4
B.84 x 501	„ & A.44 x Lun.N	10	19.7	21.8
„ x 511	„ & A.44 x B.16	3	17.1	19.2
500 x 501	A.44 x B.84 & A.44 x Lun.N	2	18.3	20.0
B.R.2 x Tj.1	Unknown & Unknown	225	18.8	20.9

Note: The first tapping panel was opened at 20 inches from the ground in

IX

ated November 1942, Field 45 A.
girth measurements and incidence of Brown Bast.

inches Dec. 950	No. of trees tapped	Yield lb. per tree per annum			Incidence of Brown Bast			
		1948–49	1949–50	1950–51	1948–49	1949–50	1950–51	Total
8.7	4	9.9	12.5	11.2	—	—	—	—
1.1	6	17.5	20.7	17.3	—	1	3	4
1.5	8	13.8	19.5	17.4	—	—	1	1
1.4	15	9.7	12.3	12.9	—	—	1	1
9.6	2	9.4	14.1	15.0	—	—	—	—
2.1	18	9.9	13.0	15.6	—	1	—	1
1.0	31	11.3	14.3	14.7	1	3	1	5
4.9	30	10.7	15.3	15.3	—	1	3	4
3.5	12	10.2	14.9	15.5	—	1	3	4
3.2	10	12.6	16.2	18.1	—	—	—	—
0.1	3	8.5	13.4	7.5	—	—	—	—
1.3	2	10.1	13.8	16.9	—	—	—	—
2.3	215	10.9	13.8	13.8	6	6	10	22

May 1948 and the second panel at 30 inches from the ground in July 1950.

TABLE X

Legitimate Seedlings, Series 12, Planted October 1943, Field 45 B.

Yield in lb. per tree per annum (160 tappings) girth measurements and incidence of Brown Bast.

Family	Parents	No. of trees measured	Girth in inches at 50 inches from the ground			No. of trees tapped	Yield lb. per tree per annum 1950	Brown Bast No.
			Jan. 1949	Dec. 1949	Dec. 1950			
Tj.1 x Lun.N -	Unknown & Unknown -	6	13.5	17.9	19.5	6	6.6	—
„ x 500 -	„ & A.44 x B.84 -	17	12.4	16.0	17.4	11	10.0	—
„ x 506 -	„ & „ „ -	30	13.3	16.9	18.6	21	9.3	—
„ x 509 -	„ & A.44 x Lun.N -	32	15.2	19.0	20.5	26	11.1	—
„ x 512 -	„ & A.44 x B.84 -	6	10.6	12.6	15.5	4	6.4	—
„ x 523 -	„ & A.44 x B.16 -	10	11.1	15.2	17.7	5	6.8	—
„ x 524 -	„ & „ „ -	3	10.8	14.1	16.2	3	3.7	—
„ x 525 -	„ & B.84 x D.65 -	5	13.3	17.2	18.5	4	8.9	—
Lun.N x 529 -	„ & „ „ -	2	12.6	15.4	17.6	1	8.4	—
505 x Lun.N -	A.44 x Lun.N & Unknown -	27	12.8	15.9	17.7	19	5.5	—
„ x B.84 -	„ „ & „ -	10	14.9	19.2	21.0	10	5.7	—
„ x 514 -	„ „ & A.44 x B.58 -	46	15.8	19.2	20.9	39	9.0	1
514 x 500 -	A.44 x B.58 & A.44 x B.84 -	16	16.4	19.8	20.7	13	13.5	1
„ x 501 -	„ „ & A.44 x Lun.N -	30	14.3	17.7	18.9	27	7.6	—
„ x 506 -	„ „ & A.44 x B.84 -	25	15.1	18.4	19.7	21	10.8	—
„ x Lun.N -	„ „ & Unknown -	43	16.2	19.4	20.7	38	8.9	—

Note: Tapping cuts opened at 20 inches from the ground in January 1950.

rather heavy but only one tree out of 27 has been broken in the wind whereas at the Proefstation, West Java, wind damage was severe.

Series 10.

This series was planted as stumps in Field 38A in November 1941. (Table VIII). The field was opened from jungle and planted on contour in 1939. The fallen jungle was not burnt and the vigorous secondary growth was kept under control by periodic slashing. It was slashed just before planting and again during the Japanese occupation towards the end of 1942. After that the secondary jungle was allowed to grow unchecked until the end of 1945 by which time the rubber trees had suffered greatly from competition with the natural growths and had grown tall and spindly. The buddings of B.84 which were used as a control suffered even more severely than the seedlings and in consequence have little value as a control, at any rate during the first few years of tapping. Once the secondary jungle growths were brought under control the trees girthed rapidly and tapping commenced in June 1947 when the trees were six and a half years old.

The largest and most interesting family is Tj.1 x B.84. Both parents are high yielders and have been shown to be producers of high-yielding seedlings when crossed with many different clones but when crossed with each other the yields are not outstanding and the incidence of brown bast is high. Considering their early history the trees of this family are very well grown but the renewed bark of many trees tends to be bumpy and corrugated.

Series 11 and 12.

Series 11 was planted in Field 45A during the Japanese occupation in November 1942 as two-year-old stumps. (Table IX). The field had been clean-cleared and at the time of the reoccupation was under a mixture of grasses and various creepers with a high proportion of lalang. Growth was greatly retarded and tapping did not commence until May 1948.

Series 12 was planted in Field 45B as two-year-old stumps in October 1943 and the conditions for growth appear to have been even more unfavourable than in

Field 45A. (Table X). At the time of the reoccupation most of the field was under heavy lalang. Since several of the families in this series also occur in series 11, the two series can be considered together.

The highest yielding family in series 11 comes from the cross Tj.1 x 500. In this series there are only six trees in tapping of this cross but that the family is high yielding in its early years is confirmed by the yields from the same cross in series 9 and 12. In the former series the yields declined after the second year and the incidence of brown bast was high. In series 11 the incidence of brown bast is also high though it has not yet appeared in series 12.

The high yields of Tj.1 x 523 in the eleventh series are not confirmed by the yields in the twelfth and the trees are for the most part poorly grown with a tendency to lean.

The family Tj.1 x 527 is moderately well grown and gives fair yields. The bark characters are good and the heavy development of cork of 527 is found in nearly all the seedlings. The incidence of brown bast may, however, prove heavy.

Tj.1 x 528 is an exceptionally well grown family of seedlings with a fair initial yield and a good rate of increase. The bark characters are good and the renewed bark is smooth.

The yields of B.84 x 501 confirm the good results obtained in the ninth series.

The large family B.R.2 x Tj.1 gives fair yields though there is a tendency for the stems to lean slightly. The virgin bark is smooth but the renewed bark is sometimes rather corrugated.

Clone 514 which was used for the time in series 12 inherits the rather weak growth of Pilmoor B.58 and is below average in vigour for clones of the 500 series. However, three of the five families of crosses with this clone are amongst the most vigorous in the series. The yields of the five families vary considerably, that of 514 x 501 one of the poorest.

The secondary characters of these families are on the whole poor; generally the bark is thin and there is a tendency for the stems to be fluted. It cannot be said to what extent these defects can be attributed to the bad conditions experienced during the early years of growth but it seems unlikely that 514 will prove a good parent clone.

(4) The Effect of Inbreeding

The crossing of two normally self-pollinated plants frequently produces offspring which are larger and more vigorous than the average of the two parents. On the other hand it has been shown (Sharp *op. cit.*) that self-pollinated seedlings of rubber trees which are normally out-pollinated may be far below the average in vigour. It can also be shown that crosses between nearly related trees are likely to be of less than average vigour.

In the ninth series of crosses the following clones were crossed in all possible combinations:

Clone		Parentage
R.R.I.501	..	A.44 x Lun. N
„ 504	..	„ x „
„ 509	..	„ x „
„ 500	..	A.44 x B.84
„ 511	..	A.44 x B.16
Tj.1	..	Unknown

Fourteen families of seedlings were obtained, one cross, 501 x 504, proving sterile and producing no seeds.

The first three clones are sibs (sisters or brothers), the next two, having one parent in common, are half-sibs, and Tj.1 is unrelated to any of the others.

The fourteen families can be divided into four groups according to the closeness of the relationship of their parents. The girths and yields of the families and the means weighted for the number of trees in each group are set out in Table XI.

Girth. In the first two groups there is no relationship between the parents of any of the five families and the mean girths of groups A and B do not differ significantly. Both parents of the seven families in group C are the children of A.44 and the mean girth is significantly lower than that of groups A and B. In group D which consists of the two families from crosses between sibs the mean girths is significantly lower than those of the other three groups. The depressing effect on vigour of inbreeding is thus clearly demonstrated. It is believed that this effect is common in rubber as it is in many other species but it may not be universal and it is possible that it may not be found in the descendants of all clones.

TABLE XI

Crosses between closely related parents.

Relationship	Family	No. of trees tapped	Girth 1949 inches	Total Yield 1946-1948 lb. per tree
A. None (a) -	501 x Tj.1	24	27.9	47.2
	504 x Tj.1	62	28.8	41.1
	509 x Tj.1	5	31.7	63.3
Mean -			28.7	43.9
B. None (b) -	500 x Tj.1	8	30.8	51.7
	511 x Tj.1	11	27.8	31.3
Mean -			29.1	39.9
C. Half sibs -	500 x 501	7	23.5	34.1
	500 x 504	70	26.0	38.7
	500 x 509	1	23.3	37.0
	500 x 511	8	26.8	40.5
	501 x 511	34	27.5	45.7
	504 x 511	56	25.4	34.7
	509 x 511	6	25.3	33.4
Mean -			26.0	38.5
D. Sibs -	501 x 509	6	19.5	25.5
	504 x 509	37	22.5	35.3
Mean -			22.1	33.9

Standard error of the mean girths = $\pm$ 0.60 inches.
„ „ „ „ yields = $\pm$ 3.08 pounds.

Yields. Although there is an indication that the mean yields follow a similar pattern to the mean girths the differences are not significant and no conclusion with

regard to their differences can be drawn with confidence. This is not altogether unexpected for it is known that girth is only one of the many factors which determine the yield of a tree and the relationship between yield and girth between families of seedlings is unlikely to be close.

It may be inferred from the results that as a general rule in any field set aside for the production of seed for commercial planting it would be unwise to include two closely related clones unless the value of the crosses of these two clones is known to be high.

(5) The Occurrence of Trees with Yellow Foliage

Trees with yellow foliage have been found only in the eighth series of crosses and only in families P.B.86 x B.84 and P.B.24 x B.84. No yellow seedlings were found in the crosses between these two Prang Besar clones and Av.157 or Tj.1 nor did they occur in any of the other crosses with B.84. The yields and girth of the yellow and green seedlings in the two families in which they occurred are given below.

Family	Foliage	Total Planted	Died before 1947	Tapped 1947	Girth at 50 inches in 1948	Yield 1947 per tree per tapping
					inches	gms
P.B.86 x B.84 -	Green	33	8	20	23.2	40.8
	Yellow	16	7	5	16.4	19.2
P.B.24 x B.84 -	Green	29	11	16	24.0	55.6
	Yellow	12	4	5	20.0	41.2

Compared with the green seedlings the yellows in family P.B.86 x B.84 showed a higher mortality in the field, weaker growth and poorer yields. In the other family, P.B.24 x B.84, the girth and yield of the yellows are inferior to the greens though to a lesser degree but no difference in the mortality has been observed.

The leaves of the yellow seedlings in these two families are similar to the second group described by Chittenden (1950) and turn green by the time they are fully expanded after which no apparent difference between the two groups can be recognised. None the less it would

be advisable to discard all yellow seedlings in the nursery for they would obviously make inferior planting material.

(6) Choice of Seed Parents

Having reviewed the characteristics of the more important families of seedlings it is clear that certain clones are far more valuable as seed parents than others. It is therefore desirable to examine the data to see which if any of the clones used in the five series of crosses would be suitable for planting in fields of mixed clones set aside for the production of seed for commercial planting.

In the five series of crosses described Tjirandji 1 has been used in more combinations than any other clone and it is probably one of the best parent clones now known, although its seedlings are on the whole liable to develop brown bast.

Avros 157, though only used as a parent in the eighth series, is possibly as good as Tj.1 and its seedlings appear to be less susceptible to brown bast than those of Tj.1.

Prang Besar 49 is also an outstanding parent and produces vigorous high-yielding families of seedlings with a comparatively low incidence of brown bast.

Pilmoor B.84 has produced one particularly good family when crossed with Av.157 but is probably of less value as a parent than Tj.1 and Av.157 and since it is also a shy seed-bearer, it might be better to omit it from a seed garden.

Of the new R.R.I. clones Nos. 501 and 509 appear very promising parents provided they are not crossed with other clones of the 500 Series which have A.44 as a parent that is with clones 500-524.

The family A.44 x Lun. N in the third series of crosses was the best family discovered in the first stage of Breeding and Selection. Clone Lunderston N has, in the later series, proved a producer of good yielding seedling families though in general it has been found difficult to cross and is not prolific seed-bearer.

On the other hand it is very clear that certain clones are likely to be undesirable seed parents. P.B.86 is a heavy seed-bearer and generally produces seedlings of less than average yield and growth. B.D.5 and Gl.1 are also below the average. The seedlings of P.B.24, Av.33 and R.R.I.500 though vigorous and high yielding are susceptible to brown bast and it would be inadvisable to use them in a seed garden.

TABLE XII

Records from small-scale trials of clones selected for further testing.

Clone	Parents of Mother trees	Year budded	No. of trees tapped 1950	Av. Girth in inches at 50 in. from union Aug. 1950	Tickness of virgin bark m.m.	Yield in lb. per tree per annum 1947	1948	1949	1950	1947-1950 B.B. Cases
R.R.I.600	Tj.1 x P.B.86 -	1939	7	32.3	9.0	20.5	24.4	23.2	26.8	2
	Control -					8.1	8.2	9.0	9.9	
„ 601	Tj.1 x Gl.1 -	„	6	28.8	9.4	10.5	16.2	16.3	16.4	1
	Control -					3.8	5.0	5.3	5.0	
„ 602	Tj.1 x Gl.1 -	„	7	32.9	10.2	13.2	17.7	20.8	20.9	—
	Control -					4.8	5.2	3.8	4.9	
„ 603	P.B.86 x B.84 -	„	7	34.6	10.1	14.6	17.3	18.1	21.2	1
	Control -					7.9	6.9	6.7	9.1	
„ 604	Tj.1 x P.B.49 -	„	7	36.0	10.2	15.3	18.0	20.1	22.2	2
	Control -					4.9	4.7	4.9	5.1	
„ 605	Tj.1 x P.B.49 -	„	7	29.6	9.2	17.3	25.8	27.1	19.5	1
	Control -					4.9	4.7	4.9	5.1	
„ 606	Tj.1 x P.B.49 -	„	7	33.4	8.9	11.6	15.7	21.6	22.9	1
	Control -					3.2	2.8	1.7	3.6	
„ 607	Tj.1 x P.B.49 -	„	7	35.1	9.6	15.2	18.8	21.3	20.5	1
	Control -					4.9	4.7	4.9	5.1	
„ 608	Av.33 x Tj.1 -	„	7	30.9	8.6	9.6	17.5	18.6	18.1	—
	Control -					4.9	6.0	4.3	5.3	
„ 609	Av.157 x B.D.5 -	„	6	30.3	9.2	9.5	14.3	15.5	13.2	1
	Control -					5.6	4.8	4.8	6.9	
„ 610	504 x Tj.1 -	1940	7	30.9	8.1	14.1	19.7	21.0	18.2	—
	Control -					6.9	8.7	7.8	6.1	
„ 611	504 x Tj.1 -	„	6	32.0	9.6	13.8	18.3	21.8	22.6	1
	Control -					5.5	7.5	8.6	8.6	
„ 612	Av.157 x P.B.49 -	1939	6	37.9	10.5	11.4	11.4	17.1	17.6	—
	Control -					7.3	3.9	5.3	5.0	
„ 613	Tj.1 x 509 -	1940	7	27.9	8.2	12.0	18.0	18.3	14.4	—
	Control -					4.0	5.7	6.2	6.5	

„ 614	Tj.1 x 509	„	7	29.5	9.5	16.5	21.0	24.3	17.1	1
	Control					3.8	5.7	4.6	4.4	
„ 615	511 x Tj.1	1940	7	30.2	8.8	10.2	17.8	20.2	21.5	—
	Control					7.5	11.2	11.5	11.4	
„ 616	Tj.1 x 507	„	7	28.5	8.6	14.3	17.8	22.2	25.3	—
	Control					5.3	7.0	9.1	9.8	
„ 617	B.R.2 x 500	1941	6	27.4	8.1	—	13.8	14.1	13.7	—
	Control					—	4.8	5.4	7.6	
„ 618	Lun.N x 501	„	6	29.2	9.4	—	15.2	21.3	21.6	—
	Control					—	6.7	8.6	10.7	
„ 619	501 x Tj.1	1940	6	24.8	7.2	11.1	15.4	21.5	14.7	—
	Control					4.7	7.1	8.5	8.5	
„ 620	501 x 511	„	7	31.9	10.2	7.1	16.2	21.5	16.9	—
	Control					6.3	9.8	10.8	9.3	
„ 621	504 x Tj.1	„	7	27.2	8.5	7.6	11.2	20.7	17.2	—
	Control					3.0	3.6	3.6	3.7	
„ 622	Tj.1 x B.84	1941	7	30.0	8.4	—	14.9	22.6	20.5	2
	Control					—	7.4	9.5	8.9	
„ 623	P.B.49 x B.84	1939	5	35.7	8.8	23.0	20.5	22.2	19.4	1
	Control					7.3	7.3	8.7	10.3	
				Jan. 1951					1949-1950	
„ 624	Tj.1 x 529	1942	7	24.8	7.0	—	—	—	14.1	—
	Control					—	—	—	5.0	
„ 625	Tj.1 x 526	„	7	26.5	7.1	—	—	—	17.6	—
	Control					—	—	—	4.8	
„ 626	Tj.1 x 500	„	7	22.2	8.4	—	—	—	14.8	—
	Control					—	—	—	4.3	
„ 627	Tj.1 x 526	„	6	28.3	8.0	—	—	—	12.0	—
	Control					—	—	—	4.8	
„ 628	Tj.1 x 527	„	7	20.1	6.2	—	—	—	14.5	—
	Control					—	—	—	5.3	
„ 629	Tj.1 x 529	„	5	22.7	7.3	—	—	—	14.1	—
	Control					—	—	—	7.3	
„ 630	Tj.1 x 527	„	7	22.5	7.9	—	—	—	10.8	—
	Control					—	—	—	6.1	

The control clone is Pilmoor B.84.

The position can be summed up by saying that Tj.1, Av.157, Lun.N and R.R.I.501 and 509 are probably the best parents used in the five Series of crosses and could be recommended for use in seed gardens though for reasons discussed above it would be inadvisable to include in any garden two or more of the closely related clones 501, 509 and Lun.N.

(7) New Clones from Hand-Pollinated Seedlings

As has been described in section 2, at the time that the hand-pollinated seedlings were transplanted to the field, new clones were established for testing on a small scale.

Altogether some 1,700 new clones were budded in the years 1939-1942 and of these 31 have been selected for further test and given the numbers R.R.I.600 to 630.

The more important data of these clones are set out in Table XII. The fertility of the soil in the fields in which these small scale trials have been set up is very variable as can be seen from the large differences in the yields of the control. Even though the yield of B.84 may vary more than that of most clones with changes in soil type the best estimate of the value of the new clones is probably the ratio between their yields and those of the controls.

The yield of many of the clones declined in 1950, sometimes by a large amount. This can be attributed to the cutting back of the branches to provide budwood for the large scale trial and for multiplication.

For testing on a large scale clones 600-618 were budded at the Experiment Station in Field 48B in April 1950 and clones 619-630 in Field 48D in October 1950.

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Literature Cited

CHITTENDEN, R. J. The Prang Besar (Malaya) Experiments in the Selection and Propagation of Hevea. *Empire Jnl. of Expt. Ag.* 1950 **18**, 105.

DE BERGCULTURES. Aanbevolen Hevea Plant Material 1941-42. *De Bergcultures* 1941. **15**. 1692.

HUTCHINSON, J. B. & PANSE, *V. G.* Studies in Plant Breeding Technique. II The Design of Field Tests of Plant Breeding Material. *The Indian Jnl. of Ag. Science* 1937. **7**. 531.

SHARP, C. C. T. Progress of Breeding Investigations with *Hevea Brasiliensis*. The Pilmoor Crosses 1928-1931 Series *J.R.R.I.M.* 1940. **10**. 34.